WHAT IS CLAIMED IS

1. A projection optical system that projects an image on a first side onto a second plane via a plurality of lenses, comprising:

a first lens group arranged in an optical path between the first side and the second plane and having a negative refractive power;

a second lens group arranged in the optical path between the first lens group and the second plane and having a positive refractive power;

a third lens group arranged in the optical path between the second lens group and the second plane;

a fourth lens group arranged in the optical path between the third lens group and the second plane; and

a fifth lens group arranged in the optical path between the fourth lens group and the second plane and having a positive refractive power;

wherein, in a direction from the first side toward the second plane, an clear aperture of a lens surface or an outer diameter of a lens in the projection optical system increases in the first lens group, changes from increasing to decreasing in the second lens group, changes from decreasing to increasing in the third lens group, and monotonically

decreases in the fifth lens group, and

wherein a condition

$1.7 < Mx2/Mn3 < 4$

is satisfied, wherein Mx2 is an clear aperture of a lens surface having the largest clear aperture, or outer diameter of a lens having the largest outer diameter, in the second lens group, and Mn3 is an clear aperture of a lens surface having the smallest clear aperture, or an outer diameter of a lens having the smallest outer diameter, in the third lens group, and wherein at least one lens of the plurality of lenses is held such that at least one of a position and an orientation is adjustable, and

a numerical aperture of the second plane of the projection optical system is equal to or more than 0.8.

2. The projection optical system according to claim 1, further comprising an aperture stop positioned between the third lens group and the second plane.

3. A projection optical system that projects an image on a first side onto a second plane via a plurality of lenses, comprising:

a first lens group arranged in an optical path between the first side and the second plane and having a negative refractive power;

a second lens group arranged in the optical path between the first lens group and the second plane

and having a positive refractive power;

a third lens group arranged in the optical path between the second lens group and the second plane and having a negative refractive power;

a fourth lens group arranged in the optical path between the third lens group and the second plane; and

a fifth lens group arranged in the optical path between the fourth lens group and the second plane and having a positive refractive power;

wherein an clear aperture of a lens surface or an outer diameter of a lens of second through fourth lenses from the first side among the plurality of lenses in the projection optical system monotonically increases;

wherein, in a direction from the first side toward the second plane, an clear aperture of a lens surface or an outer diameter of a lens in the projection optical system changes from increasing to decreasing in the second lens group, changes from decreasing to increasing in the third lens group, and monotonically decreases in the fifth lens group;

wherein a condition

$0.77 < Mn4/Mx4 < 1$

is satisfied, wherein Mx4 is an clear aperture of a lens surface having the largest clear aperture, or an

outer diameter of a lens having the largest outer diameter, in the fourth lens group, and Mn4 is an clear aperture of a lens surface having the smallest clear aperture, or an outer diameter of a lens having the smallest outer diameter, in the fourth lens group;

wherein at least one lens of the plurality of lenses is held such that at least one of a position and an orientation is adjustable; and

a numerical aperture on the second plane of the projection optical system is equal to or more than 0.8.

4. The projection optical system of claim 3, further including an aperture stop positioned between the third lens group and the second plane.

5. A projection optical system that projects an image on a first side onto a second plane via a plurality of lenses, comprising:

a first lens group arranged in an optical path between the first side and the second plane and having a negative refractive power;

a second lens group arranged in the optical path between the first lens group and the second group and having a positive refractive power;

a third lens group arranged in the optical path between the second lens group and the second plane and having a negative refractive power;

a fourth lens group arranged in the optical path between the third lens group and the second plane and having an aperture stop in the optical path; and

a fifth lens group arranged in the optical path between the fourth lens group and the second plane and having a positive refractive power;

wherein, an clear aperture of a lens surface of the plurality of lenses or an outer diameter of the plurality of lenses in the projection optical system has a relative maximum in the second lens group, becomes minimum in the third lens group, and a relative maximum in the third-fifth lens groups, and has only one significant minimum between the first side and the second plane,

wherein at least one lens of the plurality of lenses is held such that at least one of a position and an orientation is adjustable, and

a numerical aperture on the second plane of the projection optical system is equal to or more than 0.8.

6. The projection optical system of claim 5, wherein a gas lens arranged closest to the first side among air lenses formed by the plurality of lenses in the projection optical system has a bi-convex shape.

7. The projection optical system of claim 6, wherein a condition

$$1.7 < Mx2/Mn3 < 4$$

is satisfied, wherein Mx2 is in an clear aperture of a lens surface having the largest clear aperture, or an outer diameter of a lens having the largest outer diameter, in the second lens group, and Mn3 is an clear aperture of a lens surface having the smallest clear aperture, or an outer diameter of a lens having the smallest outer diameter, in the third lens group.

8. The projection optical system of claim 7, wherein a condition

$$0.77 < Mn4/Mx4 < 1$$

is satisfied, wherein Mx4 is in an clear aperture of a lens surface having the largest clear aperture, or an outer diameter of a lens having the largest outer diameter, in the fourth lens group, and Mn4 is in an clear aperture of a lens surface having the smallest clear aperture, or an outer diameter of a lens having the smallest outer diameter, in the fourth lens group.

9. The projection optical system of claim 8, wherein, at least one lens of each of the first to fourth lens groups is held such that at least one of a position and an orientation is adjustable.

10. The projection optical system of claim 9, wherein at least one lens positioned between the lens surface having the smallest clear aperture, or the lens having the smallest outer diameter, in the first side,

and the third lens group, and at least one lens positioned between the lens surface having the smallest clear aperture, or the lens having the smallest outer diameter, in the second plane, and the third lens group, are held such that at least one of a position and an orientation is adjustable.

11. The projection optical system of claim 10, wherein at least one lens positioned between the lens surface having the smallest clear aperture, or the lens having the smallest outer diameter, in the first side, and the third lens group, and at least one lens positioned between the lens surface having the smallest clear aperture, or the lens having the smallest outer diameter, in the second plane, and the third lens group, has a lens surface that is rotationally asymmetrical with respect to an optical axis and is held such that at least one of a position and an orientation is adjustable.

12. The projection optical system of claim 11, wherein at least one lens of the plurality of lenses in the projection optical system positioned closer to the first side than the aperture stop, and at least one lens of the plurality of lenses in the projection optical system positioned closer to the second plane than the aperture stop are held such that at least one of a position and an orientation is adjustable.

13. The projection optical system of claim 12, wherein at least one lens of the plurality of lenses in the projection optical system positioned closer to the first side than the aperture stop, and at least one lens of the plurality of lenses in the projection optical system positioned closer to the second plane than the aperture stop, have a lens surface that is rotationally asymmetrical with respect to an optical axis, and are held such that at least one of a position and an orientation is adjustable.

14. The projection optical system of claim 13, wherein

the first lens group has at least one negative lens,

the second lens group has at least one negative lens and at least three positive lenses,

the third lens group has at least two negative lenses, and

the fifth lens group has at least four positive lenses.

15. The projection optical system of claim 14, wherein at least one lens of the plurality of lenses in the projection optical system has an aspherical shaped lens surface.

16. The projection optical system of claim 15, wherein the lens having the aspherical shaped lens

surface is held such that at least one of a position and orientation is adjustable.

17. The projection optical system of claim 16, wherein the plurality of lenses in the projection optical system have at least a first aspherical lens having an aspherical lens surface, and a second aspherical lens having an aspherical lens surface, and

a condition

$0.8 < D1/D2 < 1.2$

is satisfied, wherein D1 is an clear aperture of a lens surface or an outer diameter of the first aspherical lens, and D2 is an clear aperture of a lens surface or an outer diameter of the second aspherical lens.

18. A projection exposure apparatus that projects and exposes a pattern image provided on an original onto a workpiece, comprising:

a light source that supplies exposure light;

an illumination optical system that directs the exposure light from the light source to the pattern on the original; and

the projection optical system of claim 1,

wherein the original is positioned on the first side, and the workpiece is positioned on the second plane.

19. A projection exposure apparatus that projects

and exposes a pattern image provided on an original onto a workpiece, comprising:

a light source that provides exposure light;

an illumination optical system that directs the exposure light from the light source to the pattern on the original; and

the projection optical system of claim 3,

wherein the original is positioned on the first side, and the workpiece is positioned on the second plane.

20. A projection exposure apparatus that projects and exposes a pattern image provided on an original onto a workpiece, comprising:

a light source that supplies exposure light;

an illumination optical system that directs the exposure light from the light source to the pattern on the original, and

the projection optical system of claim 5,

wherein the original is positioned on the first side, and the workpiece is positioned on the second plane.

21. A projection exposure method for projecting and exposing a pattern image provided on an original onto a workpiece, comprising the steps of:

supplying exposure light;

directing the exposure light to the pattern

on the original; and

projecting the pattern image on the original positioned on the first side onto the workpiece positioned on the second plane using the projection optical system of claim 1.

22. A projection exposure method for projecting and exposing a pattern image provided on an original to a workpiece, comprising the steps of:

supplying exposure light;

directing the exposure light to the pattern on the original; and

projecting the pattern image on the original positioned on the second plane onto the workpiece positioned on the second plane using the projection optical system of claim 3.

23. A projection exposure method for projecting and exposing a pattern image provided on an original to a workpiece, comprising the steps of:

supplying exposure light;

directing the exposure light to the pattern on the original; and

projecting the pattern on the original positioned on the first side onto the workpiece positioned on the second plane using the projection optical system of claim 5.